RENNIE CENTER
for Education Research & Policy

POLICY PERSPECTIVES

Alternative High School Math Pathways in Massachusetts: Developing an On-Ramp to Minimize College Remediation in Mathematics

Introduction

College remediation has come to light as a national epidemic. Recent research shows that as many as 43% of community college students in the United States are enrolled in a remedial class. At four-year colleges, the percentage is not much lower at nearly 30%. Nationally, over a million incoming college students must take remedial courses to acquire basic academic skills in mathematics and reading in order to take and comprehend entry-level college courses.[1]

To compound the additional expense and time that remediation costs college students, enrollment in remedial courses often derails students' persistence toward the completion of a college degree. Of the US college students who remediate in mathematics, 63% do not earn a two- or four-year degree.[2] Moreover, recent research indicates that only three to four out of ten community college students who are referred to remediation actually complete the entire sequence of remedial coursework. Most students exit in the beginning of their course sequence—almost half fail to complete the first course. Men, older students, Black students, part-time students, and students in vocational programs are less likely to progress through their full remedial course sequences.[3]

In Massachusetts public colleges, the remediation picture is no less bleak. Among 2005 public high school graduates attending state institutions of higher education, 37% (more than 7,000 public high school graduates) enrolled in at least one developmental (remedial)[4] course in their first semester in college. At community colleges the remediation rates are most alarming. Of these 2005 graduates enrolled at community colleges, 65% enrolled in at least one developmental course in their fall semester, versus 22% at state colleges and 8% at state university campuses. Twenty-nine percent of these students enrolled in a developmental *mathematics* course during the fall semester.[5]

While many students are focused on passing the Massachusetts Comprehensive Assessment System (MCAS) test in order to graduate from high school, achieving a passing grade on MCAS does not guarantee college readiness. Among students who passed the 10th grade Mathematics MCAS test at the Needs Improvement level, 50% enrolled in developmental mathematics in college, as compared to 20% of students who passed at the Proficient level and 4% at the Advanced level.[6]

1 Strong American Schools. (2008). *Diploma to Nowhere*.

2 Wirt, J., Rooney, P., Choy, S., Provasnik, S., Sen, A., & Tobin, R. (2004). *The Condition of Education 2004.* National Center for Education Statistics: Washington, DC.

3 Bailey, T., Jeong, D.W., Cho, S. (2008). *Referral, Enrollment and Completion in Developmental Education Sequences in Community Colleges*. Community College Research Center, Teachers College, Columbia University.

4 Throughout this brief the words "developmental" and "remedial" will be used to reference non-credit-bearing college courses.

5 Massachusetts Department of Education. (2008). *Massachusetts School-to-College Report, High School Class of 2005.*

6 Massachusetts Department of Education. (2008). *Massachusetts School-to-College Report, High School Class of 2005.*

At a time when earning a college diploma is a critical component in one's ability to secure a job that supplies the income necessary to own a home and support a family, it is vital that we address the problem of college remediation. If public schools are to deliver on the promise to educate all students to be proficient, we must ensure that every high school student in the Commonwealth has an adequate opportunity to succeed in college, without remediation.

The purpose of this paper is not to back away from the drive toward high standards that has led to a strong mathematics education for so many Massachusetts students. Nor is it to sidetrack the many students who thrive in the present system—those who complete advanced mathematics courses in high school, score high on college entrance and placement exams, and enter college fully prepared for any course of study.

In this position paper, the Rennie Center proposes a plan that would significantly reduce the number of students who require college remediation in mathematics, with the ultimate goal of eliminating the need for college remediation. This alternative pathway through high school mathematics would better motivate, serve, and prepare students who are currently struggling to advance through the existing progression of mathematics courses and ensure that all students receive a firm foundation in mathematics through Algebra II. In this paper, we outline Massachusetts' current procedure for college placement in mathematics, describe initiatives in other states that are addressing the challenges of remediation, and propose a new plan for high school mathematics courses designed to improve the quality of mathematics instruction and drastically reduce remediation rates.

The Costs of Remediation

High rates of college remediation have implications for the workforce and the economy. The nation loses more than $3.7 billion a year due to remediation. This figure includes $1.4 billion to provide remedial education to students who have recently completed high school.[7]

Approximately 5,700 Massachusetts public college students took remedial mathematics courses in 2005, the most recent year for which data are available.[8] The estimated amount a student pays for a remedial mathematics course depends on where the course is taken: at a community college the cost is $400; at a state college, $700; and at a state university, $1,100. Not including students attending private colleges or students requiring more than one remedial mathematics course, these figures account for approximately $3 million that students spend each year on mathematics remediation in Massachusetts colleges. However, it is estimated that student tuition covers only about 20% of public college costs, with student fees and Commonwealth contributions covering the remainder.[9]

Because remedial course enrollment is associated with a decreased likelihood of students' persisting in college long enough to attain a degree, we can also make a rough estimation of earnings loss associated with the need for remediation. Assuming national figures apply, students who take up to two remedial mathematics courses and no other remedial courses are 11% less likely to achieve a Bachelor's degree than students who need no remediation.[10] Since holders of Bachelor's degrees in Massachusetts earn on average $20,000 more per year than workers with only some college (including Associate's degrees), eliminating the need for remedial mathematics courses could increase annual earnings in Massachusetts by $126 million for each high school graduating class. Every year, each holder of a Bachelor's degree

7 Alliance for Education. (2006). *Paying Double: Inadequate High Schools and Community College Remediation.*

8 Massachusetts Department of Education. (2008). *Massachusetts School-to-College Report, High School Class of 2005.*

9 Alliance for Education. (2006). *Paying Double: Inadequate High Schools and Community College Remediation.*

10 Camara, W. J. (2003). *College Persistence, Graduation, and Remediation.* College Board.

contributes on average $2,400 more to the state coffers (through taxes and decreased need for transfer payments) than citizens with only some college.[11] Therefore, we can make a rough estimate that for each high school class graduating without the need for remediation in mathematics, the state would receive $1.5 million in additional annual revenues. Over ten years, as each new class adds to this annual increase, the Commonwealth would see $82.5 million in revenue that it will not receive if remediation rates persist at their current level.

The Current Mathematics Pathway: An Express Train to Calculus

The current progression of mathematics courses (Algebra I, Geometry, Algebra II, Precalculus, Calculus) has left some mathematics educators concerned that the press for greater rigor has become too narrow a push for "further, faster." While many students thrive in the current system, mastering Algebra I in 8th grade and even earning college credit in high school for high scores in AP Calculus or Statistics, others struggle, give up, or skim the surface without full comprehension or retention of the material they encounter. Evidence for this statement can be found in the research of the American College Testing Service (ACT) on high school course-taking. ACT finds that while taking more mathematics courses in high school predicts a higher ACT mathematics score, even students who have taken four years of "rigorous" mathematics are likely to stumble on previously covered material. In fact, only 73% of students who have taken high school Calculus meet the ACT benchmark score that gives them a 50% chance of achieving a B in College Algebra—a course offered one or two full courses earlier than Calculus.[12]

Thus, it appears that while some students truly master high school mathematics, other students may pass their mathematics courses by remembering only enough to do well on tests immediately after content is presented while forgetting key material soon after. A third group of students either barely gets by with no semblance of mastery over their coursework or fails altogether. All but the first group include many students likely to need remediation once they reach college. We need an alternative pathway through high school mathematics to better motivate, educate, and prepare these students as they master mathematics through the level of Algebra II and beyond. This brief describes one approach to developing such a pathway.

ACCUPLACER®, the Gatekeeper

A Massachusetts high school student planning to attend a public college faces a sequence of tests: MCAS, the SAT or ACT, and ACCUPLACER®. The student is least likely to prepare for or understand the importance of ACCUPLACER®. ACCUPLACER® is a suite of untimed computer-adaptive placement tests produced by the College Board to assess reading, writing, and mathematics skills. The mathematics test has three levels: Arithmetic, Elementary Algebra, and College Level Mathematics. ACCUPLACER® is not a Massachusetts-specific test like MCAS; it is used in over 1,300 high schools/postsecondary institutions in all US states and in over 30 countries.[13] ACCUPLACER® is intended to help college administrators evaluate academic skills retained by the student at the time of the test and use this information to place them into appropriate courses. A student's test score is designed to indicate areas in which he or she is strong and areas in which help is needed, giving students the opportunity to effectively prepare for required college-level courses by taking remedial coursework beforehand.

11 McLaughlin, Joseph, et.al. (2007). *State and Local Fiscal Consequences of High School Dropout Problems in Massachusetts.* Center for Labor Market Studies, Northeastern University.

12 ACT. (2006). *Benefits of a High School Core Curriculum.*

13 Retrieved from College Board ACCUPLACER® website, http://www.collegeboard.com/student/testing/accuplacer/accuplacer-tests.html.

Many students do not understand that passing MCAS, even at the Proficient or Advanced level, does not guarantee college readiness as measured by the ACCUPLACER® Elementary Algebra test. State policy in Massachusetts requires a cut-score of 82 out of a possible 120 points on the Elementary Algebra test for placement in college credit-bearing mathematics courses including College Algebra. Students who score well on the Elementary Algebra test may progress to the College Level Mathematics test for placement in higher-level college mathematics courses.

What do students need to know to perform well on the ACCUPLACER® tests? The tests focus heavily on two of the strands addressed in the Massachusetts curriculum frameworks: the Number Sense and Operations strand, and the Patterns, Relations, and Algebra strand.

The Arithmetic test contains a number of word problems, including rate, percentage, and measurement problems, and focuses on the arithmetic of whole and rational numbers (fractions, decimals, and percents). The Elementary Algebra test addresses operations with integers and rational numbers; operations with algebraic expressions including multiplying and dividing polynomials; simplifying algebraic expressions; evaluating positive rational roots, and exponents; simplifying algebraic fractions; factoring polynomials; and solving linear and quadratic equations, linear inequalities, and word problems.[14]

All of this content is represented in both the Massachusetts Algebra I standards and in the grade 9-10 mathematics standards for students taking an integrated mathematics course through high school. Therefore, as long as schools align courses to the Massachusetts Mathematics Curriculum Framework, the problem is not that students have never been exposed to the material covered on the ACCUPLACER® Elementary Algebra test. Rather, it is likely that some students have not mastered the material at sufficient depth.[15] This interpretation is supported by the fact that 50% of students who pass MCAS at the Needs Improvement level are subsequently placed into remedial mathematics in college, versus only 20% of those who pass at the Proficient level and 4% of those who pass at the Advanced level.[16] Other students may fail to retain what they have learned. Many of these students avoid taking mathematics in their last year (or two) of high school, and upon college entry have a hard time summoning up what they once "knew."

Emphasizing ACCUPLACER® at Worcester State College

In 2004, 54% of entering students at Worcester State College attained ACCUPLACER® scores that placed them in remedial mathematics courses. In 2005, the college initiated a policy requiring all freshmen to take a practice ACCUPLACER® prior to sitting for the actual test. Remediation rates fell to 36%. In 2006, the college required any student who failed the practice test to take an additional practice test. Students who failed the second test were required to attend a two-hour mathematics review before sitting for the actual ACCUPLACER® test. That year, only 23.5% of students were placed in remedial mathematics. A subsequent study revealed no statistically significant difference in the performance of students who passed the ACCUPLACER® test after a two-hour review session and those who passed the test after having passed a practice test.

The college has also continually sought to improve its offering of remedial mathematics courses in order to increase successful transitions to credit-bearing mathematics courses. Students are required to achieve an overall average score of at least 70% on course exams and quizzes to be eligible for retaking ACCUPLACER.® They are offered extra help and opportunities to retake course exams in order to meet this goal. Early evidence suggests that these policies have substantially lowered the failure rate for remedial classes.

14 Retrieved from College Board ACCUPLACER® website, http://www.collegeboard.com/student/testing/accuplacer/accuplacer-tests.html.

15 For a comparison of sample MCAS and ACCUPLACER® questions, see Professor Richard Bisk's presentation: "Factors Impacting Readiness for College Mathematics" presented to the College Board on April 25, 2008. http://wwwfac.worcester.edu/mathematics/rbisk/college_board_42308%20for%20web%20site.pdf

16 Massachusetts Department of Education. (2008). *Massachusetts School-to-College Report, High School Class of 2005.*

State Strategies for Reducing Remediation in Mathematics

Many states are addressing the importance of college readiness in mathematics by increasing course-taking requirements in high school. To date, 18 states require a fourth year of high school mathematics in order to graduate.[17] In Massachusetts, the Board of Elementary and Secondary Education voted to approve the Massachusetts High School Program of Studies (MassCore), which recommends that students take four years of mathematics, but does not require it. Currently, only 26% of Massachusetts districts require four years of mathematics; 67% require three years; and 7% require just two years.

Another strategy states are considering to ensure readiness for college mathematics is adoption of the new Algebra II end-of-course proficiency exam developed by Achieve's American Diploma Project in collaboration with 15 participating states. Massachusetts has piloted this test as a voluntary measure for Algebra II students in several schools, but has not committed to full deployment. Current reports indicate the test is very challenging and student scores nationwide have been low. Over time and with considerable professional development for teachers, this test may become a useful tool to show that students have met a benchmark of rigorous preparation for college.

Some states have found other ways to address the alignment of high school and college expectations in mathematics. The following are selected states' initiatives that may inform future changes in policy and practice in Massachusetts.

California

More than 60% of the nearly 40,000 first-time freshmen admitted to the California State University (CSU) system require remedial education in English, mathematics or both. These 25,000 freshmen have all taken the required college preparatory curriculum and earned at least a B grade point average in high school. In order to address this challenge, the CSU established the Early Assessment Program (EAP) along with the State Board of Education (SBE), and the California Department of Education (CDE). The program was established to provide opportunities for students to measure their readiness for college-level English and mathematics in their junior year of high school, and to facilitate opportunities for them to improve their skills during their senior year to better prepare them for credit-bearing coursework upon entry in college.

Students who opt to take the EAP test (last year, 70% of students did) find out if they are on the path to place into credit-bearing courses in college. Those who pass the test automatically qualify to take credit-bearing courses at a Cal State campus. Those who do not pass have their entire senior year to address deficiencies. In 2008, 44% of students participating in EAP did not demonstrate college readiness in mathematics. In order to address the needs of these students, the CSU has developed a number of initiatives to assist educators, students and parents in raising students' level of mathematics competency.

For more information on EAP, please visit: http://www.calstate.edu/eap/about.shtml.

Florida

In June 2008, Florida enacted a law that made two significant changes to common placement testing for public postsecondary education: 1) expanding college and career readiness assessment of high school students indicating an interest in postsecondary education, and 2) extending opportunities for remediation to high school seniors. Called the Expanded Postsecondary Readiness Assessment (EPRA), this project, for which the Florida State Legislature appropriated $700,000, will focus on expanding the delivery of the Florida College Entry-Level Placement Test—ACCUPLACER®—to more high school students.

EPRA testing will not be mandatory, but will be an option for students who indicate an interest in postsecondary education. Students who score at or

17 American Diploma Project: Math Works. *The Value of the 4th Year of Math presentation.* Achieve. Retrieved from: http://www.achieve.org/files/Achieve-MathematicsWorks-PPT-4thYearMath.ppt.

above the cut score will have the opportunity for dual enrollment in an Intermediate Algebra course—a three-semester-hour college credit course that may count as elective credit during their senior year; or students may be guaranteed entry to postsecondary, college-level coursework without need for remediation within two years of taking the test.

For more information on EPRA, visit: http://www.fldoe.org/gr/li/CCRI_EPRA-QA.pdf.

Texas

The Charles A. Dana Center, a research unit of the University of Texas Austin's College of Natural Sciences, has launched a number of initiatives focused on improving mathematics education and better aligning the K-12 and higher education systems. Recently, the Dana Center and the Texas Association of Supervisors of Mathematics worked together to "develop a rigorous, relevant course to follow Algebra II, and to address important math concepts not currently addressed in the traditional progression." Titled Advanced Mathematical Decision Making (AMDM), this course is a fourth year mathematics requirement for non-STEM majors or for workforce training programs that is designed to follow Algebra I, Geometry, and Algebra II. The course will be piloted in the 2009-2010 school year.

AMDM is designed to be an engaging and rigorous course that prepares students for a range of future options in non-mathematics-intensive college majors or for entering workforce training programs, but may also present an appealing option for students pursuing pre-calculus and calculus. The course emphasizes statistics and financial applications, and prepares students to use algebra, geometry, trigonometry, and discrete mathematics to model a range of situations and solve problems.

For more information on AMDM, visit: http://www.utdanacenter.org/amdm.

Washington

Washington State has launched the Transition Math Project (TMP), a collaborative project bringing together educators from K-12 schools, community and technical colleges, and baccalaureate institutions to "help all students prepare and be ready for postsecondary, college-level mathematics." Forty-five percent of high school graduates entering Washington's two-year colleges directly after high school need to take pre-college mathematics before they are ready for credit-bearing mathematics courses. TMP is designed to reverse this trend by helping students successfully progress from high school mathematics to college-level mathematics. With the participation of high school and college mathematics educators, TMP has identified the mathematics skills and knowledge high school graduates need to complete college-level work, meet minimum admissions requirements and avoid remediation upon enrolling in college.

TMP has accomplished several goals, including:

- Established local/regional partnerships with high school and college instructors.
- Designed a standards-based 11th/12th grade mathematics bridge course as an alternative to the traditional pre-calculus/calculus sequence. (The course is taught by K-12 and college faculty.)
- Conducted cross-sector high school teacher/college faculty visitations, including team teaching, modeling lessons and observations.

For more information on the Washington Transition Math Project, please visit: http://www.transitionmathproject.org/.

A New Pathway for Massachusetts

Massachusetts needs a differentiated approach to meet the diverse mathematical needs of students. For some students, the narrow set of course options in mathematics is not working—as our remediation rates show. Despite our acknowledged high achievement as a state, we still have large numbers of students arriving at our colleges so shaky in their fundamental skills in arithmetic (primarily rational numbers) and elementary algebra that their chances of ever receiving a college degree are severely compromised.

It is possible to envision a much more effective system, one that offers a seamless transition from middle school to high school to college mathematics. Such a system would begin with measures to ensure that students leave middle school with a strong foundation in arithmetic of whole numbers, integers, and rational numbers. Currently, about 50% of students in Massachusetts public schools are taking Algebra by 8th grade. Before enrolling in Algebra, students should be given a diagnostic test to gauge their level of arithmetic mastery. Before and during high school, diagnostic testing and course performance should continue to provide guidance for students on whether they are ready to proceed with advanced material or need more time to deepen and consolidate skills and concepts already introduced. The Massachusetts mathematics frameworks would articulate a set of "college-ready" standards mutually developed by college and high school faculty. Students could take an assessment of mathematics readiness based on these standards while still in 11th grade. Those who do well could proceed to an advanced 12th grade mathematics course (perhaps co-taught by college faculty and bearing Massachusetts college credit) while still in high school.

Students whose 11th grade test results showed residual gaps in readiness would be guided into a high-quality 12th grade course to address their particular needs. This course would consolidate existing mathematics skills and allow students to use these skills in challenging and relevant contexts. Students would be motivated to work hard by the knowledge that doing well in this course would adequately prepare them for college mathematics without remediation. Ideally, this whole articulated system would be supported by professional development for teachers, by visits back and forth among college and high school faculty, and by common final course examinations to ensure a consistent level of rigor.

Massachusetts cannot immediately establish such a well-aligned system, but we can begin to move in this direction. The following steps describe our recommendations for how to begin. We follow author David Conley in defining readiness for college mathematics.

Applying Mathematical Knowledge in Writing at University Park Campus School, Worcester

At the University Park Campus School, consistently recognized as a high-achieving school serving low-income students, mathematics teachers take a deliberate, comprehensive approach to supporting shaky mathematics learners. Students are encouraged to use multiple approaches and all the tools at hand in solving problems, and they are constantly required to explain their thinking, even writing "Dear Confused" letters to hypothetical colleagues struggling to understand difficult concepts. Small successes are recognized, and wrong answers are valued as a template for understanding and explaining misconceptions.

> *Most important for success in college mathematics is a thorough understanding of the basic concepts, principles, and techniques of Algebra. This is different than simply having been exposed to these ideas. College-ready students possess more than a formulaic understanding of mathematics. They have the ability to apply conceptual understandings in order to extract a problem from a context, use mathematics to solve the problem, and then interpret the solution back into the context. They know when and how to estimate to determine the reasonableness of answers and can use a calculator appropriately as a tool, not a crutch.*[18]

The goal of the plan described below is to provide multiple opportunities for students to achieve this deeper level of mathematical understanding.

1. Ensure mastery of arithmetic by the end of seventh grade.

Students struggle in the transition to algebra if they lack fluency with arithmetic facts and concepts. By the end of grade seven, students should be adept in

18 Conley, D. T. (2007). *Redefining College Readiness.* Educational Policy Improvement Center: Eugene, OR, p. 15. Retrieved March 13, 2009 from https://www.epiconline.org/files/pdf/Redefining_College_Readiness.pdf.

adding, subtracting, multiplying and dividing whole numbers, integers, fractions and decimals. They should have a well-founded understanding of why these procedures work and when to apply them. Students who are still shaky in these skills should take an 8th grade course that provides realistic contexts and applications so that they can solidify their arithmetic skills, extract the algebraic principles underlying arithmetic algorithms, investigate linear relationships, and demonstrate depth of understanding by applying skills and procedures in multiple contexts.[19] In our proposed course progression (see page 10), we suggest that these students have an opportunity to take a course in 8th grade that we are calling "Algebraic Approach to Arithmetic Review."

As part of its effort to improve students' understanding of arithmetic, the Commonwealth has already increased the rigor of the elementary educator licensure math test. We recommend that the upcoming mathematics framework revision should make very clear what fundamental arithmetic skills should be mastered at what grade level.

2. Focus on mastery and application of algebraic concepts.

At the high school level, we recommend that schools pay close attention to students' ability to retain and apply the knowledge they have gained. High schools should be encouraged to work toward real mastery of Algebra I before moving students on to Algebra II. For students who pass Algebra I without full mastery, schools and districts should consider offering a "Bridge to Algebra II" course in grade 10 or 11. Such a course could focus on applications of linear and quadratic relationships, while also previewing such Algebra II material as exponential and logarithmic functions.

It is important to recognize that students who fall behind in mathematics need more than just another chance at the material. They need to gain confidence, re-engage with the excitement of intellectual work, and learn new approaches to studying, understanding and remembering. These new approaches should include "habits of mind" such as visualizing relationships, looking for patterns, making conjectures, describing approaches, and tinkering with relationships.[20] Because of the challenging pedagogy involved, classes for these students should be taught by the most inspiring and skillful teachers. Teachers should be offered support and, ideally, extra compensation for this work.

ACCUPLACER® at Taconic High in Pittsfield

Taconic High School in Pittsfield administers the ACCUPLACER® to all juniors at the beginning of the school year. As a result, students can gauge whether or not they are ready for college coursework while they still have two years of high school to take additional courses and build the skills they will need to pass the ACCUPLACER® and be successful in college courses.

3. Offer the ACCUPLACER® test to high school juniors.

All students who consider attending the state public college system should be offered the chance to take both the Arithmetic and Elementary Algebra ACCUPLACER® tests toward the end of grade 11; students who scored below the Proficient level on the grade 10 MCAS should be required to do so. These students will be on Educational Proficiency Plans, and the Elementary Algebra ACCUPLACER® is one of three approved tools for measuring these students' continued progress toward proficiency. (See box on page 9.) Some schools and districts are already implementing or considering implementation of ACCUPLACER® to fulfill this requirement. In November 2008, Boston's Mayor Thomas Menino

19 One way to communicate the necessity of fluency in arithmetic to students, parents, and teachers might be to dedicate a part of the MCAS exam in grades 3-8 to simple ("naked") arithmetic problems. Students should examine arithmetic in an "algebraic" way, looking for patterns and gaining facility with turning problem descriptions into mathematical expressions and equations.

20 Cuoco, A; Goldenberg, E. P., and J. Mark. (1997). Habits of mind: An organizing principle for mathematics curriculum. *Journal of Mathematical Behavior,* 15(4), 375-402.

About the Massachusetts Educational Proficiency Plan (EPP)

In part to reduce college remediation rates, the Massachusetts Board of Elementary and Secondary Education adopted the Educational Proficiency Plan (EPP) as regulation in October 2006. This new regulation was intended to significantly increase the proportion of Massachusetts high school students who attain Proficiency or higher on the Commonwealth's 10th grade standards in English language arts and mathematics. The regulation requires that students, starting with the graduating Class of 2010, must satisfy one of the following two conditions in both English language arts and mathematics to earn a competency determination: 1.) meet or exceed the Proficient scaled score of 240 on the English Language Arts and Mathematics grade 10 MCAS tests, or 2.) meet or exceed the Needs Improvement scaled score of 220 on the English Language Arts and Mathematics grade 10 MCAS tests and fulfill the requirements of an Educational Proficiency Plan. The regulation requires that schools develop an EPP for the subject matter area(s) English language arts and/or mathematics in which students did not meet or exceed a scaled score of 240. At a minimum the EPP requires: 1.) a review of the student's strengths and weaknesses, based on MCAS and other assessment results, coursework, grades, and teacher input; 2.) identification of the courses the student will be required to take and successfully complete in grades 11 and 12; and 3.) a description of the assessment(s) the school will administer on at least an annual basis to determine if the student is moving toward proficiency, or has become proficient on the grade 10 standards.

recommended that the Boston Public Schools expand administration of ACCUPLACER® beginning in grade 11 to "assess students' readiness for college-level courses, and provide the necessary academic supports to reduce the need for remedial courses in the first year of college."

4. Provide guidance based on the Elementary Algebra ACCUPLACER® score.

Students who score 82 or higher on the Elementary Algebra ACCUPLACER® test will have demonstrated their readiness for entry-level credit-bearing college mathematics courses. They will be strongly urged to take a senior year mathematics course that continues to build their skills. Performing well in such a course should allow them to enter a credit-bearing college course without retaking the Elementary Algebra ACCUPLACER.®[21]

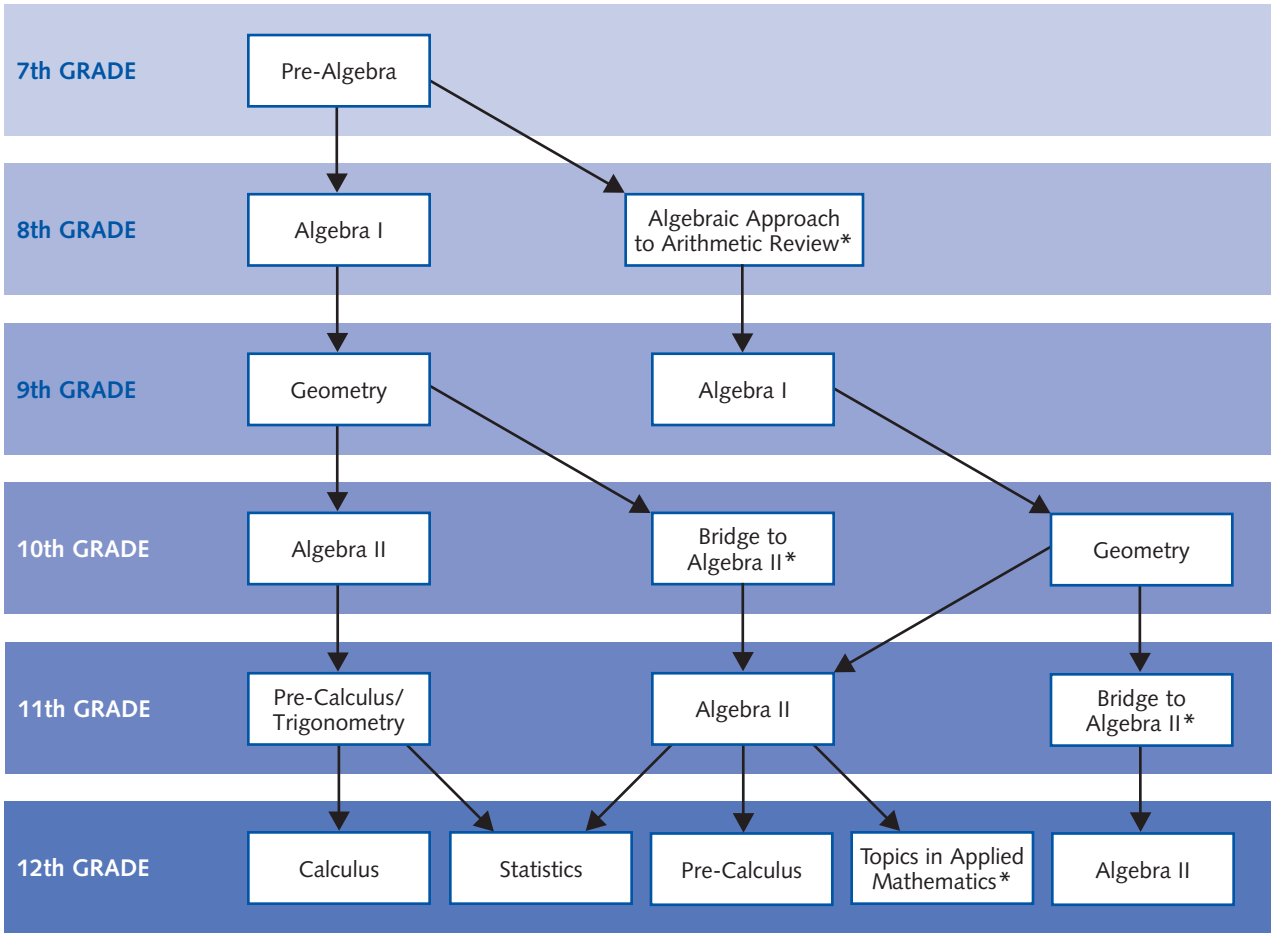
Students who score below 82 would enroll in a mathematics course geared toward strengthening their fundamental algebra skills. One option would be a new course tentatively titled "Topics in Applied Mathematics for College Preparation."[22] (A draft course outline can be found in Appendix A, along with links to other similar fourth year mathematics courses.) We recommend that this course be jointly designed by college and high school faculty along with Department of Elementary and Secondary Education (ESE) staff to be at least equivalent in rigor to the highest level college remedial course. Students statewide should take a common final exam in this course, and passing the course should require demonstrating a level of proficiency that college faculty agree satisfies any public college or university's mathematics remediation requirement.

Students in the Topics in Applied Mathematics course would retake the ACCUPLACER® at the end of their senior year, with their success on the test being one measure of the course's effectiveness. Over time, the common final exam and grading for this course may become sufficiently well-aligned with college expectations that retaking the ACCUPLACER® would not be necessary. Instead, remediation placement could be avoided by achieving a high final grade in this course.

21 Because of current concerns that fundamental skills may degenerate even as students take more advanced courses, the first cohorts of students to follow this path may need to retake the Elementary Algebra ACCUPLACER® exam on college entry to establish a track record of program success.

22 The "Topics in Applied Mathematics for College Preparation" course proposed here is just one option for a fourth year high school math course–other options like the Advanced Mathematics Decision Making courses at University of Texas should be considered. The essential characteristics of any alternative fourth year course should be: 1) that it is jointly developed and approved by high school and college faculty and, 2) that it is as rigorous as the highest level remedial college math course.

Possible Organization of High School Math Pathways



* Proposed new course

5. Encourage all students to take mathematics during their first college semester.

Students should continue their mathematics education early in their college careers while their high school coursework is still fresh in their minds. This will allow them the greatest chance of success in their first course, as well as the greatest flexibility in choosing a major and career. High school mathematics and guidance departments should collaborate with college admissions and orientation staff to ensure that students receive this message.

How to Get There From Here

The plan we have outlined here consists of a number of steps, some requiring policy changes and some requiring initial or ongoing funding. One step that colleges and high schools can take immediately is to urge students to prepare for the placement test and take it seriously. Wherever possible, information about the ACCUPLACER® and expected levels of performance should be communicated to students before they arrive on campus. Colleges may wish to adopt a requirement for practice tests and review sessions for students who fail them.

The next step is to convene a working group of high school and college faculty to develop a new high school capstone Topics in Applied Mathematics course (see Appendix A) aimed particularly at students who are on an Educational Proficiency Plan or have otherwise demonstrated that they are not fully prepared for precalculus or calculus. This course should then be piloted, with professional development and support, in several high schools. Students taking the course should be pre- and post-tested with the Elementary Algebra ACCUPLACER® test

as well as other instruments. It is important to emphasize that this course is not meant as test-prep for ACCUPLACER,® but rather as a course that develops the type of College Knowledge that David Conley describes and on which Massachusetts faculty could further elaborate.[23]

In order to determine the effectiveness of this course, students involved in the pilot should be monitored in college to measure their success in their first college mathematics courses. As formative feedback comes in from high schools, colleges, and the students themselves, the course should be refined and offered in more schools. The state should support this scale-up with funding for professional development and curriculum materials. Scale-up might include online offerings of either the Topics in Applied Mathematics course itself or professional development and support for new teachers of the course. At this point, and based on feedback from schools, the Massachusetts Department of Elementary and Secondary Education should also explore support for a Bridge to Algebra II course to consolidate skills earlier in high school.

Meanwhile, the state should provide funding to allow any 11th grader and selected 12th graders to take the Arithmetic and Elementary Algebra ACCUPLACER® test (at a cost of about $1 per test). Test results should be accompanied by guidance to the student about which 12th grade mathematics class is most appropriate for him/her to take.

The state higher education system should consider accepting ACCUPLACER® scores that are 18 months old. This policy change would mean that students who passed the test in grade 11 and successfully completed an advanced course in grade 12 would be assured a place in a credit-bearing course as long as they enroll in a mathematics course during their first college semester.

Potential Costs of the New Pathway

We estimate that an initial pilot of the new Topics in Applied Mathematics course, including the cost of administering ACCUPLACER,® course development, professional development for twenty teachers, and course materials for 400 students, would require approximately $100,000 in direct costs. Further scale-up might be expected to cost $400 to $500 per student in newly-established classrooms, a one-time start-up cost which compares favorably with the ongoing cost of remediation ($400 to $1,100 per semester course) in college. Development of an online course for teachers or students might cost another $100,000. Administering ACCUPLACER® to all 11th graders and a third of 12th graders (those who did not reach the benchmark score of 82 on the Elementary Algebra ACCUPLACER® the first time) is estimated to cost another $100,000 per year.

Similar costs might be required for professional development and materials for the course providing a bridge to Algebra II. Very substantial scale-up of this new, fortified on-ramp to college mathematics could occur at a statewide cost of $500,000 to $1 million per year. If this approach led to even a 30% drop in the need for college remediation in mathematics, the direct tuition savings to students each year would be $900,000, while the additional savings in student fees and costs to colleges can be roughly estimated at $3.6 million, without addressing the difference in earnings and income tax revenue generated by the expected increase in Bachelor's degree attainment.

Conclusion

The time has come to acknowledge that our current progression of mathematics courses leaves too many students bewildered, discouraged, or deceived by an inflated view of their own readiness for college

23 Conley, D.T. (2005). *College knowledge: What it really takes for students to succeed and what we can do to get them ready.* New York: Jossey-Bass.

study. It is unconscionable to sit idly by while large percentages of high school graduates (and disproportionate numbers of minority and low-income students) discover that they are poorly prepared in mathematics—especially when this discovery derails these students' opportunities for future success. The new, branching pathway described in this paper provides one way to make concrete the alignment of students' education from middle school through college and offers a means by which students can achieve greater mastery of fundamental mathematics. Whether this proposed plan is adopted in full, through a comprehensive pilot, or in part, through the development of specific components, is not important. What is vital is that policymakers and educators at the high school and college levels waste no time in working together to address the problem of such appalling numbers of Massachusetts high school graduates requiring remediation in mathematics.

Appendix A: Tentative Outline for *Topics in Applied Mathematics for College Preparation* Course

Course Description: This course is designed as a fourth year course option in high school. The coursework is aimed particularly at students who are on an Educational Proficiency Plan or have otherwise demonstrated that they are not fully prepared for precalculus or calculus, but may also be selected by other students as an elective math course. It is intended to prepare students for college level math - in non-math-intensive college majors.

The course will focus on the contemporary uses of mathematics and on the processes of mathematical modeling. While the course's intent is to add significant value to students' mastery of algebra and geometry, it is important to recognize the necessity for reinforcing student facility with arithmetic operations and numeracy. Moreover, practice in both reading mathematics for understanding and writing mathematics for communication will be embedded throughout the course.

While the course will be organized contextually, the expressed goal is that by the end of the course, students will have gained appropriate mastery and in-depth understanding of the following mathematical topics:

- Algebraic Skills
  - Linear equations and functions
  - Polynomial expressions
  - Factoring of polynomials
  - Functions (including functional notation and arithmetic)
  - Solving quadratic equations
- Geometry
  - Properties of parallel lines
  - Properties of triangles; especially similar triangles and slope
  - Pythagorean theorem & distance in x-y plane
  - Properties of circles
  - Area, volume
  - Coordinate systems
  - Rigid motions
- Financial Literacy
  - Exponential functions
  - Compound interest
  - Growth and decay
- Data Analysis/Statistics
  - Charts, plots and graphs
  - Linear regression
  - Equations of straight lines
  - Measures of center and spread of distributions
  - Elementary probability
- Within these topic areas, students will be expected to strengthen and generalize their knowledge and understanding of basic elements of numeracy including:
  - Arithmetic of fractions, decimals, and percents
  - Arithmetic of exponents
  - Number sense and estimation
  - Rate, ratio, and proportion

Contexts will focus on student decision making, for example, financial planning in relevant settings (student loans, buy or lease, etc.), as well as broader societal concerns (climate change, pollution control, voting, etc.)

Other promising fourth year high school math course syllabi can be found at:

- University of Texas Dana Center, Advanced Mathematical Decision Making: http://www.utdanacenter.org/amdm/downloads/amdm_june08.pdf
- Commonwealth of Virginia Bridge Course: http://www.doe.virginia.gov/VDOE/Instruction/Math/algebra_functions_data_analysis_cf.pdf
- Springfield Public Schools, MA Bridge Course: http://www.sps.springfield.ma.us/webdocs/Learning_Center_Docs/High%20School%20Curriculum%20Documents/Math/Math%20Instructional%20Guides/Math%20Applications%20MIG/MathAppsMIG0809.doc

- Revere Public Schools, MA fourth year math alternative course Functions, Statistics & Trigonometry: http://www.revereps.mec.edu/math/FST_0708.xls

For a syllabus for a Bridge to Algebra II course, please visit:

- COMAP, Modeling with Mathematics: A Bridge to Algebra II: visit http://bcs.whfreeman.com/mma/

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